

tangent from the centre to the ring, and is therefore equal to R for small rings—and μ is the cyclic constant. For a solid ring, with the same notation,

$$V = \frac{\mu}{4\pi a} \left(\log \frac{4}{k} - 2 \right).$$

In the steady motion considered, the fluid carried forward with the ring forms a single mass without aperture, even for extremely small cores, though not for infinitely small ones. For values of $R/r > 10^3$ there will be no aperture, whilst for less values the fluid carried forward will be ring-shaped. To a first approximation the energy due to the cyclic motion is the most important, and is the same as for a rigid ring at rest of the same size, it does not depend on the velocity of translation, except in so far as this determines the size of the aperture; as entering in this way the principal term varies inversely as the velocity of translation, and thus increases with diminished translatory motion, a result obtained by Sir W. Thomson* from general reasoning. The terms obtained by the second approximation arise from the translatory motion.

Lastly, the times of vibration in classes (2) and (4) above are determined, when the ring moves steadily. In class (2), or for fluted vibrations, the time of vibration for small rings is given very approximately by $\mu d / (2p \sqrt{n})$, d being the density, and p the pressure of the fluid at a great distance, whilst n is the number of crimpings in a section. This is the proof of the statement made above as to the independence of the temperature. In class (4) the time of pulsation is $(\mu d / 2p) \sqrt{(\log 4/k)}$. As k depends on the size of the ring, and therefore on the energy, this time is not independent of the latter, but varies slowly with it. The times here given must be understood as applying to rings moving steadily; when a ring is changing its size they must be modified. The investigation of this case, and of that in which there is a core of denser matter than the surrounding fluid, I hope shortly to take up.

III. "Influence of Pressure on the Temperature of Volatilization of Solids." By WILLIAM RAMSAY, Ph.D., and SYDNEY YOUNG, B.Sc. Communicated by Sir ANDREW RAMSAY, LL.D., F.R.S. Received June 5, 1883.

(Abstract.)

The experiments described in the paper were undertaken in order to ascertain whether solids have definite volatilizing points, under

* "Vortex Atoms," "Proc. Roy. Soc. Edin.," vi; "Phil. Mag.," (4), 34.

different pressures, as liquids have definite boiling points, and whether these pressures are identical with their vapour tensions.

When a liquid is heated by conduction, as for example when a flame is placed below a vessel containing liquid, till the temperature rises to its boiling point, either ebullition or superheating takes place. It would thus seem that, in the case of superheating, the surface of the liquid is not large enough to afford escape for the gaseous molecules liberated; or the convection currents are not rapid enough to convey the superheated liquid from the lower strata to the surface. If the surface is superheated, the first reason would seem to be correct; if the surface, on the other hand, is at its normal temperature, the second explanation is applicable. When ebullition takes place, the liquid increases its surface by the formation of bubbles, and as heat is totally absorbed in producing evaporation, the temperature of the liquid remains constant. If the supply of heat is increased, evaporation is also more rapid, and facility is given to more rapid evaporation, by the formation of more numerous and larger bubbles, which increase the evaporating surface.

A solid has a limited surface, which cannot be increased by formation of bubbles; and it might therefore be expected that on increasing the supply of heat, the temperature of the solid should rise, until a temperature is reached at which its rate of evaporation is equivalent to the rate at which heat is communicated to it. Reasoning thus, the existence of hot ice was maintained by Dr. Carnelley and other writers in a series of letters which appeared in "*Nature*" during the years 1881 and 1882.

On the other hand, a liquid in the spheroidal state presents a free surface of evaporation in every direction, and yet although exposed to radiation from a white-hot surface, its temperature does not rise even to the boiling point; and we find it impossible to raise the temperature of water above 90° , by applying heat to its surface. In such cases the surface appears to be large enough to allow vapour to escape with sufficient rapidity to prevent superheating.

If, then, the rate of evaporation at the surface of a solid is independent of the extent of that surface, but is influenced only by the rate at which heat is communicated to it, and, as in the case of liquids, by the pressure to which it is exposed, it follows that solids have definite temperatures of evaporation, or subliming points, corresponding to definite pressures, as liquids have definite boiling points.

Our experiments with water, acetic acid, benzene, naphthalene, and camphor, show that this is the case; and that with ice and camphor these pressures are sensibly the same as the maximum tensions of the vapours of these solids at corresponding temperatures. In the case of ice, the maximum temperature which can be attained under any given pressure is indicated by James Thomson's ice-steam line.

That the temperatures observed cannot be absolutely the same is evident; for there must be a certain excess of pressure in the neighbourhood of the surface of the solid in order to produce a flow of vapour from it to the surrounding space; and consequently the evaporating substance must have a higher temperature corresponding to this higher pressure. Our results, we venture to think, show that with solids, as with liquids, this difference, even when rapid evaporation is taking place, is an extremely minute one.

IV. "Note on the Establishment and First Results of Simultaneous Thermometric and Hygrometric Observations at Heights of 4 and 170 feet, and of Siemens' Electrical Thermometer at 260 feet above the ground." By G. J. SYMONS, F.R.S. Received June 6, 1883.

It is just a century since James Six (the inventor of the well-known Six's registering thermometer) commenced some occasional comparisons of the temperature of the air at the top and bottom of the tower of Canterbury Cathedral. We do not precisely know the position in which the instruments were placed, and, as thermometer screens had not then been invented, his observations can only be accepted as approximately correct; but as the work in which they are recorded is rather scarce, it may be well to give an analysis of the results. The observations were not consecutive, but made at various dates during 1784-92; the lower thermometer was 5 feet, and the upper one 220 feet above the ground. The daily maxima were about 1° warmer at the top during all frosty period; alike at the top and the bottom when the temperature was between 40° and 50° , and lower at the top by from 3° to 5° when the temperature was about 50° . The minima gave analogous but more marked differences. Some very severe frosts occurred while these experiments were in progress, and with bottom temperatures of $-2^{\circ}\cdot5$, $+6^{\circ}$, and $+6^{\circ}\cdot5$ respectively, the top temperatures were 15° , 17° , and 21° , showing an excess at the top of $17^{\circ}\cdot5$, 11° , and $14^{\circ}\cdot5$. In ordinary weather the excess of the top minima was not so great, but the average excess was 6° , and there was not a single night when it was colder at the top than at the bottom.

The author is not aware of any further experiments having been made upon this subject in this country until 1861, when the Rev. R. Main, F.R.S., Radcliffe Observer, had a record commenced of a Six's registering thermometer, and dry and wet bulb thermometers placed near the anemometer on the Radcliffe Observatory, Oxford. These instruments were 105 feet above the ground, and were read